Reference: *Biol. Bull.* **181:** 195–198. (August, 1991)

A Breeding Population of the Western Pacific Crab *Hemigrapsus sanguineus* (Crustacea: Decapoda: Grapsidae) Established on the Atlantic Coast of North America

JOHN J. McDERMOTT

Department of Biology, Franklin and Marshall College, Lancaster, Pennsylvania 17604

The west Pacific grapsid crab Hemigrapsus sanguineus *was found in the United States for the first time in 1988. Additional crabs were recovered in 1990 from Townsends Inlet and Cape May Harbor, New Jersey (22 males, 16 females), and four of the females collected from June through September were ovigerous. Thus,* H. sanguineus *has now established itself in southern New Jersey, the first well-documented case of an exotic brachyuran becoming established along the east coast of the United States.*

The marine grapsid crab *Hemigrapsus sanguineus* (de Haan, 1853), native to the western Pacific Ocean, was first recovered in the eastern United States in September 1988; a single ovigerous female was found in a rocky intertidal zone under a bridge at Townsends Inlet, Cape May County, New Jersey (1) (Fig. 1). The site was not reinvestigated until 20 months later (28 May 1990), and at that time an immature female *H. sanguineus* was recovered [carapace width (CW) × carapace length (CL) = 12.8 × 10.8 mm]. This second finding suggested that the original record of the crab in New Jersey was not simply fortuitous, but that this Pacific brachyuran was established in Atlantic waters. The discovery also provided a rare opportunity to document a potentially major introduction.

Subsequently, 36 additional mature and immature crabs (22 males and 14 females) (Fig. 2) were collected (26 June, 3 and 6 July, 22 August, 21 September, 15 and 28 October 1990) at the same site. Crabs were usually located in the mid to upper intertidal zone under rocks covered with *Fucus vesiculosus,* but at low tide some moved below the mid intertidal. As with many intertidal grapsid crabs that live among rocks, individuals of *H. sanguineus* are secretive and swift, and one must turn rocks over rapidly and snatch them quickly in order to catch them; otherwise, they retreat among the lower inaccessible rocks. All crabs were transported to the Franklin and Marshall laboratory where they were easily maintained individually in 2 cm of unaerated seawater (temperature 19°C, salinity ~30‰); they subsisted on pieces of the macroscopic algae *Enteromorpha* sp. and *Ulva lactuca,* and otherwise required minimal care, except for a daily water change. Crabs were measured with a dial calipers to the nearest 0.1 mm. The 22 males ranged from 8.3 to 24.1 mm CW (mean 17.2 ± 4.6), and from 7.3 to 21.0 mm CL (mean 15.2 ± 4.1); 15 females ranged from 3.6 to 24.4 mm CW (mean 17.6 ± 5.1), and from 3.3 to 21.3 mm CL (mean 15.3 ± 4.4). The greater range in females was due to one juvenile (3.6 mm), resulting from the 1990 spawning season, collected 15 October. The next smallest female was the 12.8 mm specimen collected 28 May; the smallest male (8.3 mm) was collected 26 June. These and other juveniles were probably from the 1989 spawning season.

Ovigerous females (n = 4) were found from June through September (not in July collections). One ovigerous crab, obtained on 26 June (CW × CL = 24.4 × 21.3 mm), carried embryos half filled with yolk but with no apparent pigment or eye development. The crab was preserved three days later, and the embryos were counted (n = 28,702). Two ovigerous crabs (CW × CL = 15.2 × 13.2 mm, 23.2 × 19.8 mm) were collected on 22 August. The smaller of them released its zoeae (n = 6328) two days later, and on 27 August it had another brood. Although the crab aborted many undeveloped eggs from this brood,

Received 15 November 1990; accepted 30 April 1991.

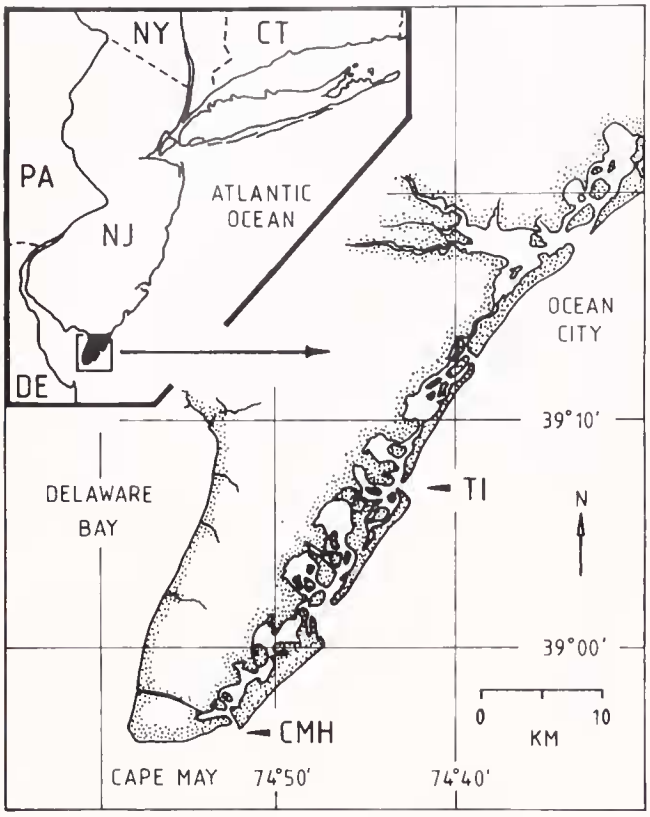

Figure 1. Sites on the Atlantic coast of the Cape May peninsula, New Jersey, where *Hemigrapsus sanguineus* has been discovered. TI = Townsends Inlet (the main study location; CMH = Cape May Harbor, which is inside of Cape May Inlet (indicated).

the zoeae (n = 3360) hatched from the remaining eggs 25 days later. The larger of the two crabs had nearly the full complement of yolk in its embryos, and released its zoeae after 17 days. Many zoeae were eaten by the crab, so the brood was not counted. One of the two females collected on 21 September (CW × CL = 19.3 × 16.8 mm) was ovigerous, and it released its zoeae the next day (n = 13,090). The first female *H. sanguineus* collected 24 September 1988 (1) was also ovigerous. Thus the egg-bearing period extends from at least June through September.

A non-ovigerous female *H. sanguineus* (CW × CL = 18.5 × 16.2 mm) was collected by Lisa Wargo sometime during January or February 1990, in Cape May Harbor (38° 57′ 12″ N, 74° 53′ 20″ W), 23.4 km south of the Townsends Inlet site (Fig. 1). This crab was one of at least three specimens, of apparently the same species; they were recovered from small clumps of mussels (*Mytilus edulis* L.) obtained in the Harbor and were maintained in an aquarium, with fish and other invertebrates, at the Cape May Point State Park. The crabs must have been very small when collected, because they were only noticed later when they were ~10 mm CW. The crab delivered to me was maintained in the aquarium until it was preserved on 18 June 1990.

H. sanguineus has become established on the ocean side of Cape May County, New Jersey, and likely will be found in environmentally suitable locations elsewhere in the state (*i.e.*, in the upper intertidal levels of rocky areas or possibly on artificial substrates suspended near the water line). This crab was probably introduced into the United States before 1988, because its presence could have been easily overlooked. New Jersey may not be *the* focal point or the *only* focal point of its introduction, and perhaps it is already established in adjoining mid-Atlantic states.

H. sanguineus is now the only other member of the genus found in the Atlantic Ocean (2,3,4), except for *H. affinis* Dana, 1851, which ranges from Cape St. Roque, Brazil, to the Gulf of San Matias, Patagonia (5). The genus is represented in the northern hemisphere of the eastern Pacific by *H. nudus* (Dana, 1851) and *H. oregonensis* (Dana, 1851) (5,6), and by *H. crenulatus* (H. Milne Edwards, 1837) in the southern hemisphere (5).

A brief résumé of its life history characteristics may give insight into the potential impact that this grapsid might have on the intertidal environment along the Atlantic seaboard. In Japan, at about the same latitude as New Jersey, *H. sanguineus* is one of the largest and most common grapsid crabs living in rocky intertidal habitats (7). It is sympatric there with at least one other abundant grapsid, *H. penicillatus* (de Haan, 1835). In the rocky intertidal of New Jersey, it may be competitive with the native brachyurans found in the same habitat; *i.e.*, three xanthids, *Eurypanopeus depressus* (Smith, 1869), *Neopanope sayi* (Smith, 1869), and *Panopeus herbstii* H. Milne Edwards, 1834; juveniles of the portunid, *Carcinus maenas* (Linnaeus, 1758); and juveniles of the cancrid, *Cancer irroratus* Say, 1817.

Fukui's studies (8) on the fecundity of *H. sanguineus* in Japan, along with my observations in New Jersey, indicate the potential for its rapid increase in Atlantic waters. Fukui determined that females may live for at least three years, the largest capable of producing more than 5 broods/year, with as many as 56,000 eggs/brood. Using Fukui's regression equation for the correlation between the number of eggs/brood and carapace width, the 35.8 mm ovigerous crab collected in 1988 (1) may have carried more than 52,000 embryos. My preliminary data, however, on brood size *versus* carapace width from the other New Jersey specimens give values somewhat greater than those predicted by Fukui's equation. In Japan, the crab's breeding season is from March to October, with the main peak in May–June (8), a period longer than the four-month season suggested by my preliminary information from New Jersey. The 25-day developmental period at 19°C, recorded for the second brood of the 15.2 mm *H.*

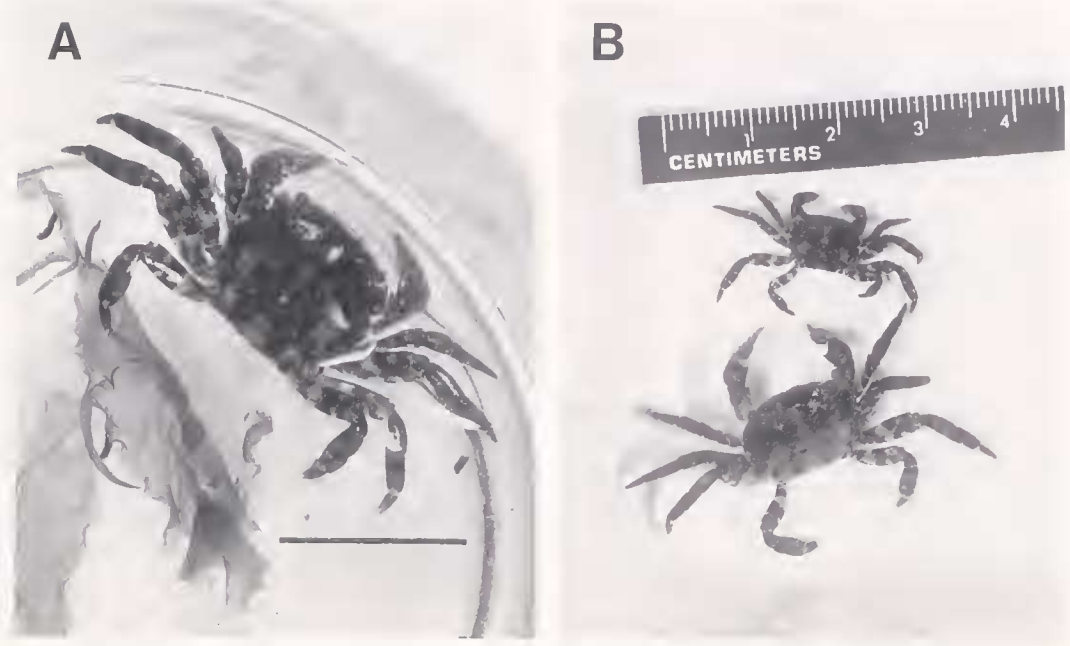

Figure 2. Three living *Hemigrapsus sanguineus* collected 26 June 1990 at Townsends Inlet, New Jersey: A. mature female, 18.5 mm CW, scale = 20 mm; B. mature male, 14.2 mm CW and immature female, 8.3 mm CW.

sanguineus mentioned above, is predicted by Fukui's regression equation for the relationship between incubation period and water temperature for embryos raised in Japan. Water temperatures in New Jersey from June through September would be conducive to the production of about four broods during this period. Fukui found that females reach maturity at 14.0 mm CW, and have a maximum CW of 39.0 mm. Thus, the 35.8 mm ovigerous female collected in New Jersey in 1988 is near the maximum size recorded for Japan, and the smallest mature crab found at Townsends Inlet (CW = 15.2 mm) is close to Fukui's value.

H. sanguineus has not been recorded from the west coast of the United States (6,9,10,11), where the only exotic brachyuran is *Rhithropanopeus harrisii* (Gould, 1841), a xanthid introduced from the Atlantic east coast. There may have been numerous attempts at colonization of the Atlantic coast of the United States and Canada by species of exotic brachyurans, but most seem to have failed prior to *H. sanguineus*. Several authors, cited by Williams (4), agree that the green crab, *C. maenas*, was probably introduced into North America from the eastern Atlantic; it now ranges from Nova Scotia to Virginia (greatest abundance in New England). The timing of such an introduction is not known, and because it could have been prehistoric, its establishment has never been documented. *Carcinus* has had considerable impact in the United States because it prefers bivalves (some commercial) as prey (12,13). The notorious Chinese mitten crab, *Eriocheir sinesis* H. Milne Edwards, 1853, has been reported in Lake Erie, but seems never to have established a breeding population in the Great Lakes (14). A single specimen of *Eriocheir* was reported from Louisiana's Mississippi River Delta region in 1987 (15,16), but has not been found again since.

H. sanguineus could have a great impact on the normal rocky intertidal environment. Therefore, the latitudinal extent of the species must be determined, its spread monitored, and its community interactions studied. Research on its further distribution in New Jersey and other mid-Atlantic states is now underway.

Acknowledgments

I thank L. Wargo, formerly of the Cape May Point State Park, New Jersey, for sending me a specimen of *H. sanguineus* from Cape May Harbor and supplying pertinent information on its collection. I am grateful to J. N. Kraeuter and R. Wargo of the Rutgers University Shellfish Research Laboratory for their assistance, to J. L. Richardson of Franklin and Marshall College and A. B. Williams of the NMFS Systematics Laboratory, Smithsonian Institution, for reviewing the manuscript, and to C. R. Shearer, Jr. and R. A. Fluck of Franklin and Marshall College for providing photographs and for help in the maintenance of crabs, respectively.

Literature Cited

1. **Williams, A. B., and J. J. McDermott. 1990.** An eastern United States record for the western Indo-Pacific crab, *Hemigrapsus san-*

gunens (Crustacea: Decapoda: Grapsidae). *Proc. Biol. Soc. Wash.* **103:** 108–109.

2. **Monod, Th. 1956.** Hippidea et Brachyura ouest-africains. *Mémoires de l'Institut Français d'Afrique Noire,* No. 45, 674 pp.
3. **Manning, R. B., and L. B. Holthuis. 1981.** West African brachyuran crabs (Crustacea: Decapoda). *Smithson. Contrib. Zool.* No. 306, 379 pp.
4. **Williams, A. B. 1984.** *Shrimps, Lobsters, and Crabs of the Atlantic Coast of the Eastern United States, Maine to Florida.* Smithsonian Institution Press, Washington, DC. 550 pp.
5. **Rathbun, M. J. 1918.** The grapsoid crabs of America. *U. S. Natl. Mus. Bull.* No. 97: 461 pp., 161 plates.
6. **Morris, R. H., D. P. Abbott, and E. C. Haderlie. 1980.** *Intertidal Invertebrates of California.* Stanford University Press, Stanford, CA. 690 pp.
7. **Sakai, T. 1976.** *Crabs of Japan and the Adjacent Seas.* Kodansha Ltd. Tokyo, 773 pp. (English text), 251 plates (many colored), 461 pp. (Japanese text), as 3 separate volumes.
8. **Fukui, Y. 1988.** Comparative studies on the life history of the grapsid crabs (Crustacea, Brachyura) inhabiting intertidal cobble and boulder shores. *Pub. Seto Mar. Biol. Lab.* **33:** 121–162.
9. **Carlton, J. T. 1979.** Introduced invertebrates of San Francisco Bay. Pp. 427–444 in *San Francisco Bay the Urbanized Estuary,* T. J. Conomos, ed. Pacific Division, American Association for the Advancement of Science, San Francisco, CA.
10. **Carlton, J. T. 1985.** Transoceanic and interoceanic dispersal of coastal marine organisms: the biology of ballast water. *Oceanog. Mar. Biol. Ann. Rev.* **23:** 313–371.
11. **Carlton, J. T. 1989.** Man's role in changing the face of the ocean: biological invasions and implications for conservation of near-shore environments. *Conserv. Biol.* **3:** 265–273.
12. **Glude, J. B. 1955.** The effects of temperature and predators on the abundance of the soft-shell clam, *Mya arenaria,* in New England. *Trans. Am. Fish. Soc.* **84:** 13–26.
13. **Ropes, J. W. 1968.** The feeding habits of the green crab, *Carcinus maenas* (L.). *Fish. Bull.* **67**: 183–203.
14. **Nepszy, S. J., and J. H. Leach. 1973.** First records of the Chinese mitten crab, *Eriocheir sinensis,* (Crustacea: Brachyura) from North America. *J. Fish. Res Bd. Can.* **30:** 1909–1910.
15. **Horwath, J. L. 1988.** Injurious wildlife: mitten crabs. Proposed rule. *Federal Register* **53**(219): 45784–45788.
16. **Horwath, J. L. 1989.** Importation or shipment of injurious wildlife: mitten crabs. Rules and regulations. *Federal Register* **54**(96): 22286–22289.